1 - INTRODUCTION

A scientifically justifiable Total Maximum Daily Load (TMDL) for a waterbody can only be developed based on a quantitative understanding of the system. In practice, water quality modeling offers a feasible tool to establish this quantitative understanding. A water quality model that is customized for a specific waterbody can simulate the major physical, chemical, and biological processes that occur in the system, and thus provide quantitative relationships between the water quality response and external forcing functions. A customized modeling framework was developed to support determination of nutrient and dissolved oxygen TMDLs for the Christina River Basin. The TMDLs are presented in the report titled ***Total Maximum Daily Loads for Nutrients and Dissolved Oxygen in the Christina River Basin, Pennsylvania-Delaware-Maryland*** (USEPA, 2005). This report is intended to accompany the TMDL report and provide a more detailed discussion on the models used for the nutrient TMDL analysis, including assumptions, parameters, and references.

The modeling framework used in this study consisted of three major components: (1) a series of watershed loading models (HSPF) developed for each of the four primary subwatersheds in the Christina River Basin (Senior and Koerkle, 2003a, 2003b, 2003c, 2003d), (2) a CSO flow model (XP-SWMM) developed by the City of Wilmington, and (3) a hydrodynamic model developed using the computational framework of the Environmental Fluid Dynamics Code (EFDC) (Hamrick, 1992). A linkage interface was also developed to allow for the transfer of model data results from the HSPF and XP-SWMM model components to the EFDC water quality model.

Under the HSPF model framework, the Christina River Basin was configured into 70 subbasins (see Figure 1-1 and Table 1-1) with each subbasin having 12 land use categories. The XP-SWMM model calculated hourly CSO flow rates from rainfall events. Storm monitoring data were used to determine event mean concentrations to estimate CSO loads for nutrients. The EFDC model framework includes the main channels of Brandywine Creek, East Branch Brandywine Creek, West Branch Brandywine Creek, Buck Run, Red Clay Creek, White Clay Creek, Christina River, Delaware River, and several other smaller tributaries. The EFDC receiving water model was linked to the HSPF and XP-SWMM models to incorporate watershed and CSO loads. The EFDC hydrodynamic and water quality model was used to predict the dissolved oxygen and nutrient concentrations in the main channels of the Christina River, Brandywine Creek, White Clay Creek, and Red Clay Creek watersheds. The water quality constituents were calibrated using monitoring data for the period October 1, 1994 to October 1, 1998 (a period of 4 years). This period included two dry summers (1995 and 1997) as well as a number of high-flow periods, both of which are important to satisfy the TMDL seasonality requirements.

Table 1-1. Subbasins in the HSPF models of Christina River Basin

Subbasin	Stream Name	Area (mi2)		Subbasin	Stream Name	Area (mi2)
Brandywine Creek Watershed				*White Clay Creek Watershed*		
B01	Upper Brandywine Creek West Br.	18.39		W01	White Clay Creek West Br.	10.23
B02	Brandywine Creek West Br.	7.38		W02	Upper White Clay Creek Middle Br.	9.51
B03	Brandywine Creek West Br.	6.76		W03	White Clay Creek Middle Br.	6.35
B04	Brandywine Creek West Br.	0.80		W04	Trib. To White Clay Creek East Br.	6.20
B05	Brandywine Creek West Br.	8.82		W05	Trib. To White Clay Creek East Br.	2.65
B06	Brandywine Creek West Br.	8.06		W06	Upper White Clay Creek East Br.	8.57
B07	Brandywine Creek West Br.	13.46		W07	Trout Run	1.37
B08	Brandywine Creek West Br.	3.62		W08	White Clay Creek East Br.	7.47
B09	Upper Brandywine Creek East Br.	14.68		W09	White Clay Creek East Br.	6.85
B10	Brandywine Creek East Br.	18.31		W10	White Clay Creek	3.58
B11	Brandywine Creek East Br.	6.31		W11	White Clay Creek	6.53
B12	Brandywine Creek East Br.	3.70		W12	White Clay Creek	8.76
B13	Brandywine Creek East Br.	7.94		W13	White Clay Creek	2.08
B14	Brandywine Creek East Br.	12.92		W14	White Clay Creek	3.41
B15	Brandywine Creek	10.36		W15	Muddy Run	3.89
B16	Brandywine Creek	14.06		W16	Pike Creek	6.65
B17	Brandywine Creek	7.51		W17	Mill Creek	13.00
B18	Brandywine Creek	10.37		*Red Clay Creek Watershed*		
B19	Brandywine Creek	8.64		R01	Upper Red Clay Creek West Br.	10.08
B20	Upper Buck Run	25.54		R02	Red Clay Creek West Br.	7.39
B21	Upper Doe Run	11.05		R03	Red Clay Creek East Br.	9.90
B22	Lower Doe Run	10.96		R04	Red Clay Creek	5.11
B23	Lower Buck Run	1.95		R05	Red Clay Creek	5.24
B24	Trib. To Broad Run	0.60		R06	Burroughs Run	7.10
B25	Broad Run	5.83		R07	Hoopes Reservoir	2.10
B26	Marsh Creek	2.61		R08	Red Clay Creek	5.38
B27	Marsh Creek	11.54		R09	Red Clay Creek	1.72
B28	Trib. To Valley Creek	2.40		*Christina River Watershed*		
B29	Valley Creek	18.21		C01	Christina River West Br.	6.70
B30	Beaver Creek	18.08		C02	Upper Christina River	9.73
B31	Pocopson Creek	9.19		C03	Christine River	4.47
B32	Birch Run	4.66		C04	Upper Little Mill Creek	5.37
B33	Rock Run	8.03		C05	Little Mill Creek	3.84
B34	Lower Brandywine Creek	6.05		C06	Muddy Run	8.64
B35	Upper Marsh Creek	5.80		C07	Belltown Run	6.37
				C08	Christina River	10.70
				C09	Lower Christina River	21.90

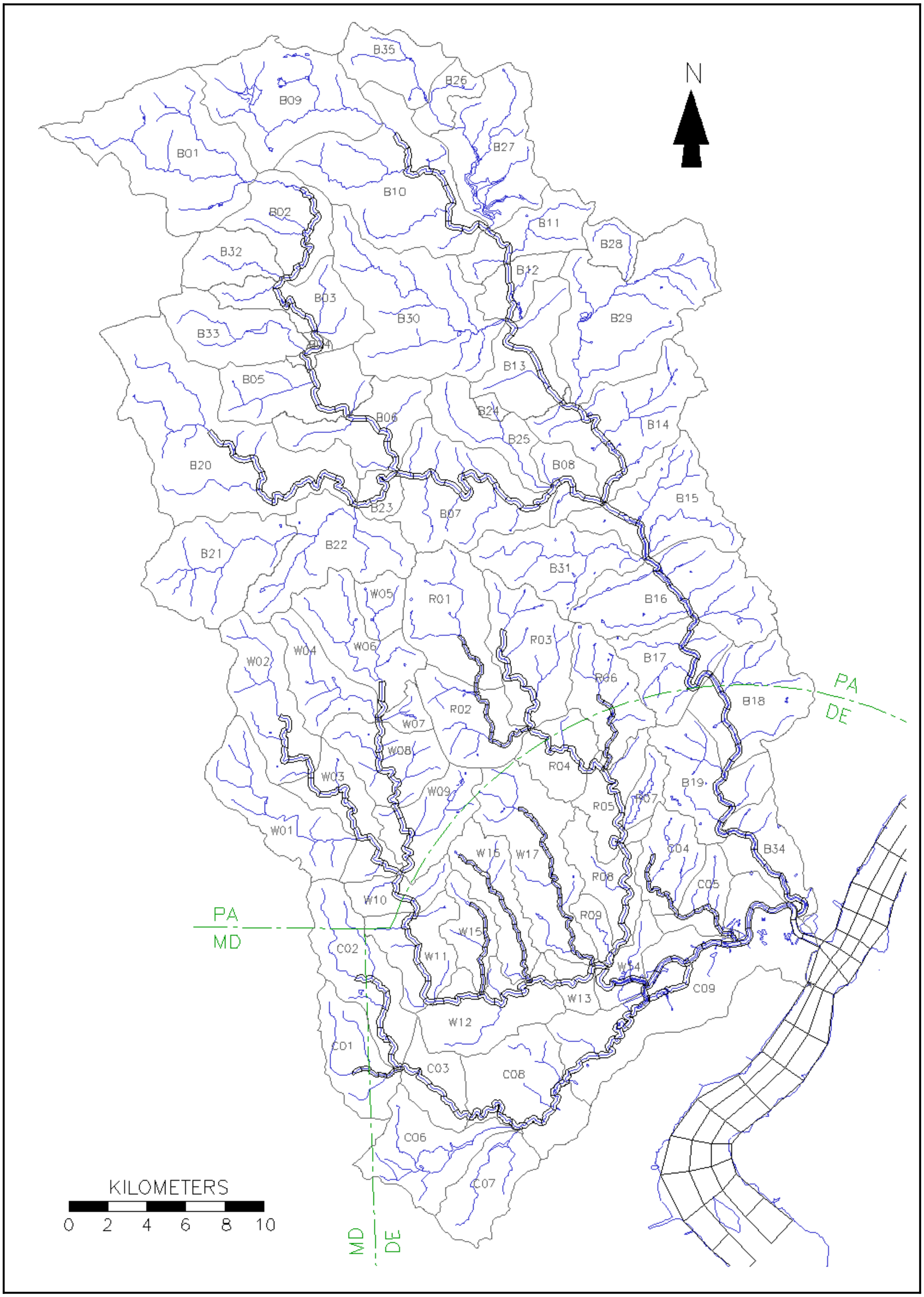

Figure 1-1. Christina River Basin showing HSPF model subbasins and EFDC model grid